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ANNUAL REPORT
Forest Disease Detection Survey: Air Pollution

Arizona and New Mexico
Region 3

Branch of Forest Insect and Disease Management
Division of Timber Management
Southwestern Region, USDA, Forest Service
517 Gold Avenue, SW
Albuquerque, New Mexico 87102

June 1974

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Region 3
517 Gold Avenue, SW
Albuquerque, New Mexico 87101

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JUN 17 1974

To All Survey Cooperators and
Interested Individuals

The enclosed report, "Forest Disease Detection Survey: Air Pollution," is for your information. The report covers the results of our 1973 survey of forests in Arizona and New Mexico for air pollution injury caused by sulfur dioxide.

The amount of injury detected in 1973 was about the same as that reported in 1972. Only a small number of areas were affected and no tree mortality was observed.

Should you need additional information, or copies of this report, please write to:

USDA, Forest Service
Division of Timber Management
Branch of Forest Insect and
Disease Management
517 Gold Avenue, SW
Albuquerque, New Mexico 87102

Sincerely,

Mark M. Johannesen

MARK M. JOHANNESEN
Assistant Regional Forester
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INTRODUCTION

Since 1971, several forested areas in the Southwest have been surveyed annually for sulfur dioxide effects. The results of the 1973 survey are presented and evaluated in this report.

METHODS

The survey included 15 old and new "observation areas" (Table 1). Twelve old observation areas were examined where results from previous years indicated a need for continued surveillance. In addition, three new observation areas were established: two where increased emissions are expected from an existing source, and another near an old observation area where increased sulfur dioxide effects were observed in 1973. The locations of these new observation areas were selected by the same criteria used in previous years.

Vegetation in each observation area was examined for symptoms of acute sulfur dioxide injury. Broad-leaved species were examined for intercostal necrotic areas, and needle-leaved species were examined for needletip dieback and needle banding. For each species, the percentage of plants with these symptoms was recorded, based on the total number of plants examined. In addition, for broad-leaved species, the amount of intercostal necrotic area was recorded in two ways: (1) the mean percentage (to nearest 5%) of foliage affected, based on a visual estimate (10, 20, 30%, etc.) for each affected plant; and (2) the mean percentage of leaf area affected, based on a visual estimate (10, 20, 30%, etc.) for affected leaves. Also, needle-leaved species were examined to determine if needle retention was less than normal.

Color photographs were taken and collections made of most species with symptoms. Photographs were placed in the photograph file and plant collections in the herbarium of the Branch of Forest Insect and Disease Management.

Sulfation plates were exposed in some observation areas. Two plates were exposed simultaneously in some areas. Procedures used in handling and analysis were the same as those used in previous years.

Table 1.--Observation areas examined in 1973.

Admin. Unit	Observation Area No.	State	County	Legal Descrip.	Aprx. Elev. (Ft)	Direction From Nearest Source	Aprx. Dist. From Nearest Source (Miles)	Est. Size of Observation Area (Acres)	Month Exam.	Last Previous Exam.
Gila NF, Silver City RD	7	N.M.	Grant	T16S R13W S30	6,600	NW	14.5	2	Aug.	Jul. & Aug. 1972
Gila NF, Silver City RD	9	N.M.	Grant	T17S R13W S24	6,200	N	8.5	1	Aug.	Jul. & Aug. 1972
Ft. Bayard Hospital	1	N.M.	Grant	T17S R13W S25, 26	6,100	N	7.0	1	Aug.	Jul. & Aug. 1972
Coronado NF, Santa Catalina RD	1 (Peppersauce Campground)	Ariz.	Pinal	T10S R16E S28	4,600	SW	7.5	3	Aug.	Aug. 1972
Coronado NF, Santa Catalina RD	6 (Peppersauce Cave - Tule Spring)	Ariz.	Pinal	T10S R16E S33, 34	4,700	SW	8.0	1	Aug.	Aug. 1972
Tonto NF, Globe RD	4	Ariz.	Gila	T1S R15E S27	4,800	S	7.5	1	Aug.	Sep. 1972
Tonto NF Globe RD	5 (Pioneer Pass Campground)	Ariz.	Gila	T2S R15E S3	5,800	S	9.5	1	Aug.	Sep. 1972
Tonto NF Globe RD	6 (Warnica Springs Picnic Area)	Ariz.	Gila	T1S R14E S12	5,000	SW	4.0	2	Aug.	Sep. 1972

Table 1.--Observation areas examined in 1973 (continued).

Admin. Unit	Observation Area No.	State	County	Legal Descrip.	Aprx. Elev. (Ft)	Direction From Nearest Source	Aprx. Dist. From Nearest Source (Miles	Est. Size of Observation Area (Acres)	Month Exam.	Last Previous Exam.
Tonto NF Globe RD	7	Ariz.	Gila	T1S R15E S30	5,200	S	6.5	1	Aug.	Sep. 1972
Tonto NF Globe RD	10 (Kellner Campground)	Ariz.	Gila	T1S R15E S20	4,500	S	5.5	2	Aug.	Sep. 1972
Apache NF Clifton RD	2 (Granville Rec. Area)	Ariz.	Green-lee	T3S R29E S8	6,700	N	8.5	2	Sep.	Aug. 1972
Apache NF Clifton RD	2A	Ariz.	Green-lee	T3S R29E S16	6,100	N	7.5	1	Sep.	Not previously examined
Apache NF Clifton RD	5 (Coronado Spring)	Ariz.	Green-lee	T3S R29E S16	5,600	N	7.0	2	Aug. & Sep.	Aug. 1972
Petrified Forest NP	1 (Admin. Site)	Ariz.	Apache	T19N R24E S10	5,500	E	30.0	2	Sep.	Not previously examined
Petrified Forest NP	2	Ariz.	Apache	T18N R24E S4, 9	5,500	E	28.5	1	Sep.	Not previously examined

RESULTS

Occurrence of foliage symptoms at each observation area and results from sulfation plates exposed at four of the areas are discussed and summarized in Tables 2 through 15.

Silver City Ranger District, Gila National Forest

Observation Areas 7 and 9.--Intercostal necrotic areas were not observed on broad-leaved species, and needletip dieback or needle banding was not observed on needle-leaved species examined (Tables 2 and 3). This year's findings and those of previous years suggest that continued annual examination of these areas is unnnecessary.

Fort Bayard Hospital

Lombardy poplar and Siberian elm were examined. Intercostal necrotic areas were observed on the foliage of 2 of 10 Lombardy poplars. Less than 10 percent of the leaves on the two trees were affected. The mean percentage of leaf area affected was about 25 percent. Similar symptoms were not observed on Siberian elm. Sulfation plate data collected a short distance from the observation area are presented in Table 4. No data are available from previous years for comparison with 1973 data.

While intercostal necrotic areas were observed on one species, only two plant species were examined in the observation area. To determine whether acute sulfur dioxide injury has occurred, it is important to examine several species. The observation area should either be discontinued or relocated where a greater variety of species can be examined.

Santa Catalina Ranger District, Coronado National Forest

Observation Area 1.--Intercostal necrotic areas were not observed on broad-leaved species (Table 5). This is in contrast with 1972, when symptoms of acute sulfur dioxide injury were reported in the area. Sulfation rates were higher in February and lower in August and September than during the same months in 1972. In both 1972 and 1973, sulfation rates were below the detectable minimum in May, June, and July (Table 4). This area should be examined again in 1974.

Observation Area 6.--Intercostal necrotic areas were observed on two broad-leaved species (Table 6). Because only a small proportion of the species examined were affected, a conclusion that sulfur dioxide injury has occurred is not justified. Confirmation of sulfur dioxide injury would require more information than is now available on the sensitivity of the affected species to sulfur dioxide relative to other species present. This area should be examined again in 1974.

Table 2.--Summary of data from observation area 7, Silver City Ranger District, Gila National Forest, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas			Herbarium specimen No.	Photo No.	Additional observations
		% plants affected	% leaves affected	% leaf area affected			
Mullein	3	0					
Globe mallow	1	0					
Arizona walnut	3	0					
Gray oak	1	0					
Brickellia	6	0					Mechanical injury to foliage
Willow	3	0					Foliage chlorotic
Arizona alder	4	0					One tree 5' ht. had chlorotic foliage
Scarlet sumac	10	0				1	Galls; mechanical injury to foliage (Photo No. 1)
Canyon grape	4	0					

Needle-leaved species examined	No. plants examined	% plants with needle-tip dieback	% plants with needle banding	Age of needles affected	Needle retention	Herbarium specimen No.	Photo No.	Additional observations
Ponderosa pine	7	0	0		Normal			Common fleck on older needles; some on current year's needles
Pinyon pine	3	0	0		Normal			

Table 3.--Summary of data from observation area 9, Silver City Ranger District, Gila National Forest, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas			Herbarium specimen No.	Photo No.	Additional observations
		% plants affected	% leaves affected	% leaf area affected			
Skunkbush	8	0					
Globe mallow	7	0					Mechanical injury to foliage
Sunflower	7	0					
Canyon grape	2	0					

Table 4.--Sulfation plate data collected at four locations in 1973.

Location	Month	Days exposed	*Sulfation rate (Micrograms $SO_3/cm^2/day$) Plate 1	Plate 2
Fort Bayard Hospital	Jun.	27	<1.5	<1.5
	Jul.	34	2.9	3.7
	Aug.	43	2.0	2.3
	Sep.	15	--	2.7
Coronado National Forest, Santa Catalina Ranger District	Feb.	29	4.2	4.2
	Mar.	32	<1.3	<1.3
	Apr.	29	2.0	<1.4
	May	31	--	<1.3
	Jun.	31	<1.3	<1.3
	Jul.	29	<1.4	--
	Aug.	30	--	<1.4
	Sep.	35	<1.2	<1.2
Tonto National Forest, Globe Ranger District	Feb.	29	5.0	
	Mar.	31	<1.3	
	Apr.	29	2.0	
	May	30	2.9	
	Jun.	32	2.7	
	Jul.	30	3.3	
	Aug.	31	4.5	
	Sep.	33	<1.2	
Apache National Forest, Clifton Ranger District	Jun.	29	<1.4	<1.4
	Jul.	--	--	--
	Aug.	23	4.3	4.3

*Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

Table 5 .--Summary of data from observation area 1, Santa Catalina Ranger District, Coronado National Forest, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas			Herbarium specimen No.	Photo No.	Additional observations
		% plants affected	% leaves affected	% leaf area affected			
Arizona white oak	6	0					
Arizona sycamore	10	0					
Brickellia	20	0					
Skunkbush	13	0					
Arizona walnut	9	0					
Canyon grape	10	0					
Sacred datura	4	0					
Catclaw acacia	6	0					
Hackberry	8	0					
Horehound	8	0			56		
Common chokecherry	1	0			57		Mechanical injury to foliage
Pigeonberry	10	0			64		
Sweet clover	8	0					
Mesquite	1	0					

Table 6.--Summary of data from observation area 6, Santa Catalina Ranger District, Coronado National Forest, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas			Herbarium specimen No.	Photo No.	Additional observations
		% plants affected	% leaves affected	% leaf area affected			
Arizona white oak	2	0					
Arizona sycamore	1	0					
Arizona walnut	2	0					
Brickellia	12	25	10	15	62	91	Mechanical injury to foliage
Conyza	6	100	40	10	63	94	Pattern of intercostal necrotic areas not as
							distinct as in some other species
Four-o'clock	1	0			61		
Willow	7	0					
Canyon grape	4	0					
Hackberry	4	0					
Skunkbush	3	0					
Ash	5	0					
Sorrel	9	0			60	92, 93	Brown spots on foliage

Globe Ranger District, Tonto National Forest

Observation Areas 4, 5, 7, and 10.--Intercostal necrotic areas were not observed on broad-leaved species, and needletip dieback or needle banding was not observed on needle-leaved species (Tables 7, 8, 9, and 10). These areas should be examined again in 1974.

Observation Area 6.--In this observation area, intercostal necrotic areas were observed on several broad-leaved species. Needletip dieback and needle banding occurred on one needle-leaved species (Table 11).

Presence of similar symptoms on several broad-leaved species indicates that acute sulfur dioxide injury occurred in the observation area. The number of species affected in area 6 was greater than reported in 1972.

Sulfation plate data are presented in Table 4. Sulfation rates were lower in February, March, April, May, July, and September, and higher in June and August than for the same months in 1972.

Symptoms observed on one ponderosa pine, i.e. dieback and banding of current year's needles, and a less than full needle complement, along with the occurrence of symptoms on associated broad-leaved species, indicate that the tree may have been injured by sulfur dioxide. This is questionable, however, since the sensitivity of ponderosa pine to sulfur dioxide relative to most of the injured broad-leaved species in the area is unknown. Also, none of the other ponderosa pine examined were similarly affected.

Observation area 6 should be examined again in 1974. A ground or aerial survey to determine the extent of injury in the vicinity of the observation area would be desirable.

Table 7 .--Summary of data from observation area 4, Globe Ranger District, Tonto National Forest, 19..

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas			Herbarium specimen No.	Photo No.	Additional observations
		% plants affected	% leaves affected	% leaf area affected			
Brickellia	24	0			52		
Arizona sycamore	10	0					
Skunkbush	4	0					
Canyon grape	6	0					
Bee-balm	2	0					
Arizona white oak	9	0					
Catclaw acacia	2	0					
Hollyleaf buckthorn	4	0					
Goldenrod	8	0			53		
New Mexican locust	5	0					
Arizona walnut	3	0			54		Small brown spots on leaflets
Globe mallow	1	0					
Sacred datura	1	0			51		Mechanical injury to foliage
Lamb's-quarter	1	0					
Sweet clover	4	0					

Needle-leaved species examined	No. plants examined	% plants with needle-tip dieback	% plants with needle banding	Age of needles affected	Needle retention	Herbarium specimen No.	Photo No.	Additional observations
Ponderosa pine	8	0	0		Normal			Common flecks on older needles

Table 8 .--Summary of data from observation area 5, Globe Ranger District, Tonto National Forest, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas			Herbarium specimen No.	Photo No.	Additional observations
		% plants affected	% leaves affected	% leaf area affected			
Brickellia	13	0			50		Mechanical injury to foliage
Canyon grape	7	0					
Bee-balm	6	0			47		
Arizona white oak	1	0					
Hollyleaf buckthorn	2	0					
New Mexican locust	5	0					
Arizona walnut	14	0			48	90	Mechanical injury; dark brown spots on foliage
Arizona alder	2	0					
Globe mallow	11	0					
Virginia creeper	5	0			45		
Common chokecherry	10	0					
Snowberry	9	0			44		
Cranesbill	9	0			46		
Nightshade	3	0			49		
Boxelder	5	0					
Toumey oak	4	0					
Gambel oak	6	0					

Needle-leaved species examined	No. plants examined	% plants with needle-tip dieback	% plants with needle banding	Age of needles affected	Needle retention	Herbarium specimen No.	Photo No.	Additional observations
Ponderosa pine	10	0	0		Normal			Common flecks on older needles

Table 9.--Summary of data from observation area [illegible] Globe Ranger District, Tonto National Forest, 1

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas			Herbarium specimen No.	Photo No.	Additional observations
		% plants affected	% leaves affected	% leaf area affected			
Brickellia	13	0					
Skunkbush	10	0					
Canyon grape	1	0					
Arizona white oak	6	0					
Catclaw acacia	4	0					
Hollyleaf buckthorn	5	0			34		
Goldenrod	4	0			37		
Beardtongue	3	0			36		
Toumey oak	6	0			35		

Needle-leaved species examined	No. plants examined	% plants with needle-tip dieback	% plants with needle banding	Age of needles affected	Needle retention	Herbarium specimen No.	Photo No.	Additional observations
Ponderosa pine	7	0	0		Normal			Common flecks on older needles

Table 10.--Summary of data from observation area 10, Globe Ranger District, Tonto National Forest, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas			Herbarium specimen No.	Photo No.	Additional observations
		% plants affected	% leaves affected	% leaf area affected			
Brickellia	15	0					
Arizona sycamore	7	0					
Skunkbush	13	0			41	88, 89	Reddish to yellow intercostal areas
Canyon grape	4	0					
Bee-balm	2	0					
Arizona white oak	5	0					
Fremont cottonwood	5	0					
Catclaw acacia	4	0					
Conyza	9	0			39		
Goldenrod	10	0			38		
Arizona walnut	7	0					
Arizona alder	2	0					
Lamb's-quarter	2	0			42		
Common chokecherry	1	0			43		
Sweet clover	4	0			40		
Hackberry	1	0					

Table 11.--Summary of data from observation area 6, Globe Ranger District, Tonto National Forest, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas: % plants affected	% leaves affected	% leaf area affected	Herbarium specimen No.	Photo No.	Additional observations
Brickellia	5	100	65	20	16	38	
Arizona sycamore	4	100	60	25	18	40, 41, 70	
Skunkbush	5	80	55	20	17	39	Pattern of necrotic areas irregular; large number of marginal necrotic areas
Canyon grape	4	100	35	20	19	42-47	Pattern of intercostal necrotic areas rather irregular
Bee-balm	4	75	65	25	20	48-51	
Willow	2	100	90	65	22	52-55	
Conyza	1	100	60	20	21	56-57	Pattern of intercostal necrotic areas not as distinct as in some other species; some of leaves almost entirely necrotic
Southwestern chokecherry	5	20	10	20	23	58-61	Marginal necrotic areas
Hollyleaf buckthorn	5	20	10	10	24	62, 63	
Goldenrod	5	60	55	25	25	67-69	Pattern of necrotic areas irregular; large amount of marginal necrotic area
Arizona white oak	5	20	10	30	27	71-75	
Fremont cottonwood	1	0					
Alder-leaf mountain mahogany	1	0			29		
Palmer oak	1	0			30		
Catclaw acacia	1	0			31	76-79	Marginal necrotic areas

Needle-leaved species examined	No. plants examined	% plants with needle-tip dieback	% plants with needle banding	Age of needles affected	Needle retention	Herbarium specimen No.	Photo No.	Additional observations
Ponderosa pine	12	17	8	All ages on one tree; only 1- & 2-year needles on second tree	Only current year's needles left on one tree	32, 33	80-87	

Clifton Ranger District, Apache National Forest

Observation Area 2.--Intercostal necrotic areas on broad-leaved species and needletip dieback or needle banding on needle-leaved species were not found (Table 12). This observation area should be examined again in 1974.

Observation Area 2A.--This observation area was established in 1973. Intercostal necrotic areas were observed on Arizona white oak, brickellia, conyza, netleaf oak (Herbarium specimen No. 97), and scarlet sumac. Species lacking this symptom were Arizona walnut, Fremont cottonwood, and gray oak (Herbarium specimen No. 98). Occurrence of similar symptoms on several broad-leaved species indicates that acute sulfur dioxide injury occurred in the observation area. Reexamination in 1974 is recommended.

Observation Area 5.--Intercostal necrotic areas were observed on several broad-leaved species, and needletip dieback was observed on one needle-leaved species (Table 13). Sulfation plate data collected is given in Table 4.

Occurrence of similar symptoms on several broad-leaved species indicates that acute sulfur dioxide injury occurred. The number of species affected was greater than reported in 1972.

The cause of dieback of 1- and 2-year-old needles of Mexican pinyon in observation area 5 is unknown. Dieback of older needles can be caused by several agents.

Observation area 5 should be examined again in 1974. A ground or aerial survey to determine the extent of injury in the vicinity would be desirable.

Table 12.--Summary of data from observation area 2, Clifton Ranger District, Apache National Forest, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas			Herbarium specimen No.	Photo No.	Additional observations
		% plants affected	% leaves affected	% leaf area affected			
Brickellia	20	0			93,94,95		Mechanical injury to foliage
Arizona walnut	6	0					
Silverleaf oak	3	0					
Southwestern chokecherry	7	0					
Scarlet sumac	1	0					
New Mexican locust	6	0					
Canyon grape	3	0					
Meadow rue	7	0					
Rose	5	0					
Gambel oak	10	0					
Globe mallow	4	0					
Horehound	9	0					

Needle-leaved species examined	No. plants examined	% plants with needle-tip dieback	% plants with needle banding	Age of needles affected	Needle retention	Herbarium specimen No.	Photo No.	Additional observations
Ponderosa pine	9	0	0		Normal			

Table 13.--Summary of data from observation area 5, Clifton Ranger District, Apache National Forest, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas: % plants affected	% leaves affected	% leaf area affected	Herbarium specimen No.	Photo No.	Additional observations
Brickellia	10	80	80	15	84	2	Mechanical injury to foliage
Arizona walnut	7	63	70	15	4,7,81	8,9,10, 14,15	Mechanical injury to foliage;galls;black irregular spots on leaflets in addition to brown intercostal necrotic areas;some leaflets almost entirely black (Herbarium specimen 81 & Photo No. 8 & 9)
Arizona white oak	6	100	65	30	13,86	26	Mechanical injury to foliage
Seepwillow	3	100	85	25	1	3,4	
Silverleaf oak	10	0			15,90		Mechanical injury to foliage
Conyza	5	100	60	15	3	5	Pattern of intercostal necrotic areas not as distinct as in some other species
Skunkbush	10	80	80	20	82	6,7	Pattern of necrotic areas irregular;a large number of marginal necrotic areas
Southwestern chokecherry	1	0			6	13	Marginal necrotic areas on some leaves
Scarlet sumac	12	75	60	20	8	16,17,18, 19,19A	Marginal necrotic areas on some leaves
Pointleaf manzanita	4	0			9		
New Mexican locust	6	50	25	25	14	27,28, 31	Marginal necrotic areas on some leaves
Canyon grape	3	33	50	20	11	22,23	Galls;pattern of intercostal necrotic areas rather irregular
Arizona sycamore	5	40	15	30	83	29,30 32-37	Flecks on leaves (Photo No. 29-30, 32-34)
Sacred datura	2	100	50	15	10	20,21	
Scorpionweed	2	100	90	20	12	24,25	
Netleaf oak	5	0			89		

Needle-leaved species examined	No. plants examined	% plants with needle-tip dieback	% plants with needle banding	Age of needles affected	Needle retention	Herbarium specimen No.	Photo No.	Additional observations
Mexican pinyon	2	100	0	1- & 2-year old	Normal	85	11,12	
Arizona cypress	4	0						

Petrified Forest National Park

Two observation areas were established in 1973 in anticipation of a possible future increase in sulfur dioxide emissions from a power plant near Joseph City, Arizona. Because of their distance from the source, it appears unlikely that acute sulfur dioxide injury could occur. However, the areas should be examined again, should emissions from the plant increase.

Observation Area 1.--Intercostal necrotic areas were observed on two broad-leaved species (Table 14). A conclusion that sulfur dioxide caused the injury would not be justifiable, since only a small proportion of the species and individuals examined were affected, and the intercostal necrotic areas were not typical of those usually associated with sulfur dioxide injury. The soil around the affected trees should be tested to determine if a nutrient imbalance exists.

Observation Area 2.--Intercostal necrotic areas were not observed on broad-leaved species examined (Table 15).

Table 14.--Summary of data from observation area 1, Petrified Forest National Park, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas: % plants affected	% leaves affected	% leaf area affected	Herbarium specimen No.	Photo No.	Additional observations
Texas honeylocust	4	0				95, 95A, 96	Tips of some leaflets chlorotic to necrotic
Skunkbush	5	0				98, 98A, 99	Marginal necrotic areas
Four-winged saltbush	7	0					
Flowering crab apple	2	0					
Globe mallow	4	0					
Wolfberry	4	0					
Ginkgo	1	0					
Russian olive	7	0				100,100A, 101,101A	Some of leaves chlorotic
Pinyon	3	0					
Arizona sycamore	2	See under additional observations				102,103, 104	Mechanical damage (Photo No. 104); chlorotic to necrotic intercostal areas (Photo No. 102)
Lanceleaf cottonwood	1	0			102	97,97A	Chlorotic to necrotic areas on margin of leaves
Fremont cottonwood	7	See under additional observations			101	105,106	Intercostal necrotic
						107	areas on leaves of one tree
New Mexican olive	4	0			104		

Needle-leaved species examined	No. plants examined	% plants with needle-tip dieback	% plants with needle banding	Age of needles affected	Needle retention	Herbarium specimen No.	Photo No.	Additional observations
Pinyon	3	0	0		Normal			

Table 15.--Summary of data from observation area 2, Petrified Forest National Park, 1973.

Broad-leaved species examined	No. plants examined	Intercostal necrotic areas			Herbarium specimen No.	Photo No.	Additional observations
		% plants affected	% leaves affected	% leaf area affected			
Fremont cottonwood	11	0					Extensive branch mortality
Four-winged saltbush	11	0					
Willow	10	0					
Common cocklebur	7	0					
Doveweed	4	0			105		
New Mexican olive	6	0					

DISCUSSION

The amount of acute sulfur dioxide injury detected was similar to that reported in 1972. In one observation area on the Apache National Forest and another on the Tonto National Forest, the number of species affected in 1973 was greater than reported in 1972. A scarcity of information on the relative susceptibility of native plants to sulfur dioxide injury continued to be a problem. Observations of needletip dieback on 1- and 2-year-old needles of conifers were not useful. A variety of symptoms were observed in the observation areas. Needle flecking on ponderosa pine was observed again this year. As indicated in last year's survey report, this symptom has been observed virtually throughout the ponderosa pine type of the Region, both near sulfur dioxide sources and at great distances from these sources. Confusing symptoms previously reported on Arizona walnut were observed again this year in some areas.

The survey should be continued in the several areas indicated in this report and in last year's report, and should be extended to any areas where new or increased emissions are expected. Where several years' sulfation plate data have been collected, use of sulfation plates each year may no longer be necessary.

To date, the survey has been confined mostly to the observation areas. Ground or aerial surveys should be conducted to delineate any affected areas in the vicinity of observation areas where injury has been reported.

Information on the relative susceptibility of native forest species to sulfur dioxide injury is now being obtained in a cooperative study with the University of Arizona. This information should be used in the survey as quickly as it becomes available. Hill et al. recently reported on a sulfur dioxide fumigation study of native desert vegetation. This report, while unavailable for the 1973 survey, should be useful for future surveys in Arizona and New Mexico.

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A P P E N D I X

Appendix A.--List of common names of plants used, with scientific equivalents.

Acacia, Catclaw--*Acacia greggi*
Alder, Arizona--*Alnus oblongifolia*
Ash--*Fraxinus* spp.
Beardtongue--*Penstemon palmeri*
Bee-balm--*Monarda menthaefolia*
Boxelder--*Acer negundo*
Brickellia--*Brickellia* spp.
Buckthorn, Hollyleaf--*Rhamnus crocea*
Chokecherry, Common--*Prunus virginiana*
Chokecherry, Southwestern--*Prunus virens*
Cocklebur, Common--*Xanthium strumarium*
Conyza--*Conyza coulteri*
Cottonwood, Fremont--*Populus fremontii*
Cottonwood, Lanceleaf--*P. acuminata*
Crab Apple, Flowering--*Malus* spp.
Cranesbill--*Geranium caespitosum*
Cypress, Arizona--*Cupressus arizonica*
Datura, Sacred--*Datura meteloides*
Doveweed--*Croton texensis*
Four-o'clock--*Mirabilis multiflora*
Ginkgo--*Ginkgo biloba*
Globe Mallow--*Sphaeralcea* spp.
Goldenrod--*Solidago wrightii*
Grape, Canyon--*Vitis arizonica*
Hackberry--*Celtis* spp.
Honeylocust, Texas--*Gleditsia texana*
Horehound--*Marrubium vulgare*
Lamb's-quarter--*Chenopodium album*
Locust, New Mexican--*Robinia neomexicana*
Manzanita, Pointleaf--*Arctostaphylos pungens*
Meadow Rue--*Thalictrum fendleri*
Mesquite--*Prosopis* spp.
Mountain Mahogany, Alder-leaf--*Cercocarpus montanus*
Mullein--*Verbascum* spp.
Nightshade--*Solanum* spp.
Oak, Arizona White--*Quercus arizonica*
Oak, Gambel--*Q. gambelii*
Oak, Gray--*Q. grisea*
Oak, Netleaf--*Q. reticulata*
Oak, Palmer--*Q. palmeri*
Oak, Silverleaf--*Q. hypoleucoides*
Oak, Toumey--*Q. toumeyi*
Olive, New Mexican--*Forestiera neomexicana*

Appendix A.--List of common names of plants used, with scientific equivalents (continued).

Pigeonberry--*Rivina humilis*
Pine, Ponderosa--*Pinus ponderosa*
Pinyon--*Pinus edulis*
Pinyon, Mexican--*Pinus cembroides*
Rose--*Rosa* spp.
Russian Olive--*Elaeagnus angustifolia*
Saltbush, Four-winged--*Atriplex canescens*
Scorpionweed--*Phacelia magellanica*
Seepwillow--*Baccharis glutinosa*
Skunkbush--*Rhus trilobata*
Snowberry--*Symphoricarpos utahensis*
Sorrel--*Rumax* spp.
Sumac, Scarlet--*Rhus glabra*
Sunflower--*Helianthus* spp.
Sweet Clover--*Trifolium* spp.
Sycamore, Arizona--*Platanus wrightii*
Virginia Creeper--*Parthenocissus inserta*
Walnut, Arizona--*Juglans major*
Willow--*Salix* spp.
Wolfberry--*Lycium* spp.